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ASSESSMENT OF POTENTIAL FOR BUILDING SEM-EDXA-QUANTIMET 900 AND SEM-EDXA-KONTRON IMAGE ANALYSIS SYSTEMS

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MICROMEDIA

ASSESSMENT OF POTENTIAL FOR BUILDING SEM-EDXA-QUANTIMET 900 AND SEM-EDXA-KONTRON IMAGE ANALYSIS SYSTEMS

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SUMMARY

An evaluation was made to determine whether an image analysis system composed of a scanning electron microscope (SEM), an energy dispersive X-ray analyser (EDXA), and an image analyser had a good potential for performing the image analysis measurements that are required in the Mineralogy Section, Mineral Sciences Laboratories, CANMET. The factories and R & D laboratories of Cambridge Instruments Limited and of Kontron Image Analysis Systems were visited. It was found that the software needed for integrating the SEM-EDXA-image analyser into the image analyses system that we require is not yet available, but both companies made a commitment to have it ready within several months after receiving an order.

It was concluded that the SEM-EDXA-image analyser has a better potential than the SEM-EDXA with programmed particle analysis for performing the required image analysis in the mineralogy laboratory because:

(1) the initial image can be cleaned and stored for analysis;
(2) analysis of known mineral pairs can readily be performed with an optical microscope which can be easily put on line with the image analyser;
(3) the capabilities of commercial image analysers are much broader than those of the EDXA programmed particle analysers;
(4) many grey levels can be analysed from one scan whereas with the SEM-EDXA-programmed particle analyses only the two grey levels discriminated by the SEM detector are available for analysis.

EVALUATION DES POTENTIELS DES SYSTÈMES D'ANALYSE PAR IMAGE SEM-EDXA-QUANTIMET 900 ET SEM-EDXA-KONTRON

par

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RÉSUMÉ

On a évalué un système d'analyse par image composé d'un microscope électronique à balayage (SEM), d'un analyseur à rayon X à émission d'énergie (EDXA), et d'un analyseur par image afin de déterminer s'il possède les caractéristiques nécessaires pour effectuer les mesures d'analyse par image requises par la section de la minéralogie du Laboratoire des sciences minérales du CANMET. On a visité l'usine et les laboratoires de R&D de Cambridge Instruments Limited et de Kontron Image Analysis Systems. Le logiciel requis pour intégrer l'analyseur par image SEM-EDXA au système d'analyse par image dont nous avons besoin n'est pas encore disponible, quoique les deux compagnies se soient engagées à le mettre au point en quelques mois seulement après qu'elles en aient reçu la demande.

On a conclu que l'analyseur par image SEM-EDXA semble être mieux équipé que l'analyseur de particule programmé SEM-EDXA pour accomplir les analyses par image effectuées par le laboratoire de minéralogie pour les raisons suivantes:

(1) l'image initiale peut être nettoyée et emmagasinée pour fin d'analyse;

(2) l'analyse de paires de minéraux connus peut être accomplie facilement avec un microscope optique qui peut aisément être mis en communication directe avec l'analyseur par image;

(3) les capacites des analyseurs par image commerciaux sont beaucoup plus vastes que l'analyseur de particule programmé EDXA;

(4) plusieurs degré de gris peuvent être analysés à l'aide d'une seul balayage alors que l'analyseur de particule programmé EDXA ne permet que d'en analyser deux, qui sont distingués par le détecteur SEM.

INTRODUCTION

An SEM-EDXA image analysis system is required in the Mineralogy Section of the Mineral Processing Laboratory, Mineral Sciences Laboratories, CANMET. The system should consist of: a scanning electron microscope (SEM) to produce an image; an energy dispersive X-ray analyser (EDXA) to identify the phases in the image; a wave length dispersive X-ray analyser (WDXA) to analyse selected particles in the images; and an image analyser to characterize the images. The equipment must be interconnected and fully integrated to run automatically. The image analyser portion of the analysis system can be either software programs in the EDXA or a stand-alone image analyser. The Quantimet 900 and the Kontron (IBAS 2 or SEM- 1PS) are the two stand-alone image analysers that are most generally used in Canada at the present time. The SEM-EDXA-software image analysis systems have been assessed previously. To assess the SEM-EDXA- Quantimet 900 and SEM-EDXA-Kontron image analysis systems the factories and R & D laboratories of Cambridge Instruments, Cambridge, UK, and of Kontron Image Analysis Systems, Eching, Germany were visited May 23-27 and May 30-June 3 respectively.

CAMBRIDGE INSTRUMENTS LIMITED

Personnel

The persons met at Cambridge Instruments Limited were:

Mr. Tom Kelley, Manager, Quantimet 900

Dr. Geoff Jenkinson, Manager, R & D for Quantimet

Dr. Gerald Gardiner, Manager, R & D electronics

Dr. Ralph Knowles, Manager, R & D software and electronics applications

Mr. Dennis Owens, Sales Manager, UK

Mr. S. Wilcox, Marketing Manager

Mr. John Davies, Sales, central UK

Miss Dawn Chescoe, Microstructural Studies Unit, University of Surrey

Mr. E. Samuel, Sales Manager, Link EDXA systems

Dr. Peter J. Statham, Director of Software Application Research, Link EDXA systems

The above personnel demonstrated the SEM 100, SEM 250, SEM 200, the EDXA Link 860, and the Quantimet 900 and discussed interfacing of the equipment.

Scanning Electron Microscopes (SEM)

Stereoscan 100

The Stereoscan 100 is a basic electron microscope that is simple to operate and produces good images. However, it does not have all of the features that would be required for a fully integrated image analysis system, even though it would be suitable for a simple fully automatic system. In particular the chamber has only three ports, therefore the system could not have a WDXA.

Stereoscan 250

The Stereoscan 250 is the research electron microscope of Cambridge Instruments Limited. It has high resolution and produces very high quality images. It meets all the requirements for our fully integrated image analysis system and has enough ports to install the WDXA. It is more complex to operate, but this is not envisaged as a serious problem since only three operators are expected to use it.

Stereoscan 200

The Stereoscan 200 is the newest model of the electron microscopes manufactured by Cambridge Instruments Limited. Its price range lies between the Stereoscan 100 and 250. Because it is a newly developed SEM it has some superior electronics, but it does not have all the capabilities of the 250. It appears to meet the basic requirements for our system.

Comment

One day was spent with Miss D. Chescoe at University of Surrey who is a user of Stereoscan 100, Stereoscan 250, the JEOL 35 electron microscope and several transmission electron microscope (TEMS). She preferred the quality of the images produced by the Cambridge SEM compared to the JEOL 35, although she was obviously biased towards the Cambridge SEM. On the other hand, she preferred the operation of the JEOL stage. This indicates that the Cambridge electron microscope would be suitable for our purpose.

Energy Dispersive X-ray Analysis (EDXA)

One day was spent at Link EDXA factory and R & D laboratory at High Wycombe, Bucks, England, and a demonstration of the Link 860 on-line with an old Cambridge SEM was observed. The system is easy to use and is operator-friendly, similar to all other EDXA systems observed to date. The detector appears to send a very stable X-ray beam. Analyses using ZAF correction on galena, pyrite, sphalerite and chalcopyrite gave realistic values for the elements as low as 0.5%. The ZAF correction program requires measurements of only one standard and then resets all other standards. The detection of X-ray pulses with automatic background correction seems to be sensitive and fast. A program that handles peak overlap is very effective (i.e., sulphur and lead in galena were analysed accurately using the strong peaks, which fall nearly in the same position). The long dimension of the video screen is vertical, whereas it is horizontal on the Tracor Northern EDXA. In addition, the digmap can display only four colour images on the screen at one time, vs eight for the Tracor Northern. These, however, are not considered to be serious drawbacks for our fully integrated image analysis system.

Image Analyser (Quantimet 900)

The Quantimet 900 equiped with a Plumbicon TV scanner and microscope was demonstrated. The phases in the resulting image were discriminated better than with the Quantimet 720 in the mineralogy laboratory of CANMET. In particular, the galena and pyrite in the BMS lead concentrate could be readily differentiated with the Quantimet 900 but not with the MSL Quantimet 720. Furthermore, the image can be easily cleaned up to remove pits, scratches, etc. by using erosion-dilation, size, and other techniques. This feature of cleaning the image was observed to be very significant; it makes the SEM-EDXA-Quantimet system superior to the SEM-EDXA software system. In addition, the Quantimet 900 has the capability of scaling the optical spectrum in several ways: when scaled logarithmetically, the phases with low grey levels can be differentiated more readily; and when scaled so that the high grey level of the spectrum is expanded, the phases with high grey levels can be differentiated better.

The image analysis capabilities of the Quantimet 900 have been increased several fold over the Quantimet 720 and are limited only by the operator's knowledge of the instrument and understanding of image analysis. This is another feature that makes the SEM-EDXA-Quantimet system superior to the SEM-EDXA-software system particle analyses.

Interfacing of Instruments

The R & D personnel at Cambridge Instruments Limited were not aware of the requirements for the image analysis system that we want to assemble. Before the author's arrival at Cambridge they were under the impression that their Quantimet-SEM interface, which accepts SEM images, would meet our needs. Such is not the case. Consequently, the Cambridge R & D persons spent the week of May 23-27 in discussion with R & D persons from Link Systems Limited and with the author, to develop a suitable software package. A proposal for such a package was developed and the personnel of Cambridge Instruments Limited have made the commitment that, if ordered, the package would be thoroughly tested before delivery and they would maintain surveillance of its applications.

The package would operate in such a manner that the image produced by the SEM would be accepted by the Quantimet 900. The Quantimet 900 would clean the image and would use the cleaned image for subsequent analysis. The Quantimet 900 would steer the X-ray beam to the first feature in the cleaned image and would simultaneously order the Link 860 EDXA to accept the X-ray spectrum and classify it according to a pre-determined chemistry file. The Link 860 would send the feature identity to the Quantimet 900 and the Quantimet 900 would define the size and shape of the feature.

An additional program would be written to flag features that have a special chemistry and to analyse them by WDXA. A mineral search program would also by written.

KONTRON IMAGE ANALYSIS SYSTEM

Personnel

The persons met at the Kontron Image Analysis Systems factory and R & D laboratory were:

Dr. Michael Alff, Product Manager, Image Processing Systems
Mr. Wilfrid Koeditz, Applications Engineering Manager
Mr. Roland Niederhagen, SEM-IPS Software Manger

Image Analysis System

General principles

Kontron Image Analysis Systems Limited have developed the SEM-IPS for an SEM-EDXA-image analyser. The SEM-IPS is the image analyser and it controls all aspects of the analysis. In this system the SEM is used to produce an image, and the EDXA to produce X-ray signals for specific elements. The SEM-IPS can receive X-ray signals for up to eight elements with one scan. Most EDXA systems are built to send out only four signals, although the Tracor Northern EDXA does produce eight internally and might be adapted to send them out. The SEM-IPS can receive EDXA X-ray signals (maps) for the entire field, for rasters that automatically select particles of interest, and for individual particles. The program for receiving X-ray maps of individual particles has just been written and has not yet been tested.

Six relatively poor X-ray maps were obtained for the field by scanning at a speed that covered the entire field in about five minutes. Better maps could be obtained by scanning at slower speeds. Nevertheless, the poor X-ray maps were cleaned up using a density algorithm; high density spots were detected as phases containing elements, and low density spots, which represented the background were removed. This cleaned image was superimposed on the SEM back-scatter electron image to define properly the outlines of different phases, then the image was analysed.

When individual particles are analysed a user-defined chemical classification is required in order to identify the mineral. The personnel at Kontron Image Analysis Systems propose that the classification be done in the SEM-IPS, but they have not yet written the program. As a result of the author's visit the personnel propose to write this program within three months and to include it as part of their package (optional) on all SEM-IPS units sold in the future.

During chemical classification, features with a specific pre-determined chemistry or other pre-determined parameters can be flagged and their locations registered for retrieval at the end of the run. the stage can be returned semi-automatically to locate the grains and the grains can be analysed semi-automatically with the WDXA.

Specific characteristics

The SEM-IPS is menu-operated and is as easy to use as the Quantimet 900. It has many methods of cleaning the images, including erosion-dilation, particle shape and size, etc. In addition it can clean the field using pixel density, which is a characteristic that seems to be superior to many found in the Quantimet 900. A very wide variety of image analysis operations can be performed with it, so the types of image analyses, as with the Quantimet 900, would be limited only by the capability of the operator. On the other hand, the method of analysing free and unliberated particles is not as direct as with the Quantimet 900.

One field of an SEM backscatter image which had six phases (identified with EDXA) was analysed with the SEM-IPS by detecting each phase on the basis of grey level, cleaning the field, and analysing each phase separately. The total area for the six phases was 99.87% which indicates that the analysis was accurate.

Dr. M. Alff stated that the company is updating the basic SEM-IPS analysis program to analyse free and locked features and perform de-agglomeration analyses more directly. He also stated that within two months a simple program for fibre analysis will be available. This program is listed in the brochure but is not yet available.

CONCLUSION

The visit to the two image analysis factories and R & D laboratories was necessary in order to make a proper evaluation of the available equipment, and to show the manufacturers what is needed for the SEM-EDXA-image analysis system that is proposed for the mineralogy laboratory. Neither factory had all the software that will be required for our system, although Kontron Image Analysis Systems has much of it partly written.

It became evident as soon as the author visited the factory of Cambridge Instruments Limited that without special software their equipment could not meet our need. Consequently, their Cambridge research engineers put together a proposal for writing the needed software as soon as an order is received. If the order is not placed with them, they will probably write the software anyway and offer it as part of their options, at a much later date. This is because similar, but inexplicit, requests have been received before.

The Kontron Image Analysis Systems have developed more programs for a fully integrated image analysis system than Cambridge Instruments Limited. Nevertheless, some programs have not yet been fully tested, and some programs are still not written.

One of the objectives of visiting the factories was to determine whether an SEM-EDXA programmed particle analysis or an SEM-EDXA-image analyser would hold the best potential for meeting the image analysis requirements in the mineralogy laboratory. It was concluded that the SEM-EDXA-image analyser is the best system because:

(1) the image analyser can clean up the SEM image, store it in memory, then send a signal back from the cleaned image to the SEM to analyse the features;
(2) the image analyser can subdivide the many grey levels that fall within the grey level range selected by the backscatter detector of the SEM and classify the subdivided grey levels into separate bins for further classification on the basis of chemistry;
(3) the capabilities of the image analyser are much greater than those of programmed particle analysis, therefore, the possibilities for solving a wider scope of image analysis problems are much better with the image analyser;
(4) the image analyser can use an optical microscope for performing the analysis when the phases are known and there is a high contrast between phases. This condition is met frequently enough to be a significant consideration.